LICH. 1982. Food habits of Bald Eagles in Maine. *J. Wildl. Manage.* 46:636–645.

WATSON, J.W., M.G. GARRETT, AND R.G. ANTHONY. 1991. Foraging ecology of Bald Eagles in the Columbia River estuary. *J. Wildl. Manage.* 55:492–499.

WHITE, C.M., W.B. EMISON, AND F.S.L. WILLIAMSON. 1971. Dynamics of raptor populations on Amchitka Island, Alaska. *BioScience* 21:623–627.

———, F.S.L. WILLIAMSON, AND W.B. EMISON. 1977. Avifaunal Investigations. Pages 227–260 *in* M.L. Merritt and R.G. Fuller [EDS.], The environment of Amchitka Island, Alaska. National Technical Information Service, Springfield, VA U.S.A.

WILLIAMSON, F.S.L., C.M. WHITE, AND W.B. EMISON. 1975. The birds of Amchitka Island. Department of Zoology, Brigham Young University, Provo, UT U.S.A.

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SURVIVAL AND BEHAVIOR OF A ONE-FOOTED MADAGASCAR FISH-EAGLE IN THE WILD

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The ability of a one-footed raptor to survive long-term in the wild has been considered questionable (Cooper et al. 1980, Durham 1981). While there are accounts of the survival of one-legged raptors in captivity (Cooper 1985) and of those admitted from the wild to a raptor clinic (Durham 1981), we could only locate two published accounts detailing the known survival of one-footed raptors in the wild. Blodget et al. (1990) document the 2-yr survival in the wild of a one-footed immature Bald Eagle (*Haliaeetus leucocephalus*) and Eggenhuizen (1995) documents the 1-mo survival in the wild of a one-legged adult Eurasian Kestrel (*Falco tinnunculus*), killed ultimately by impact with a vehicle. Avian anatomical constraints (McKeever 1979, Cooper 1985) and species-specific foraging strategies (Cooper et al. 1980) suggest that one-footed raptors have a diminished capacity for long-term survival in the wild. Here, we report the 7-yr survival, in the wild, of a one-footed adult male Madagascar Fish-Eagle (*Haliaeetus vociferoides*) and document his behavior and social status within a polyandrous breeding trio.

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STUDY AREA AND METHODS

The Peregrine Fund initiated the Madagascar Fish-Eagle Conservation Program on Madagascar's western seaboard in 1991, to study the species' ecology and breeding behavior (Watson et al. 1993). Through 2001, over 100 Madagascar Fish-Eagles were trapped and banded with a uniquely numbered embossed aluminum band and a series of colored plastic or colored aluminum bands for individual identification. The majority of fish-eagles were trapped at lakes in the Manambolomaty River floodplain (19°00′S, 44°30′E) in the Antsalova region of western Madagascar, ca. 300 km west of the capital, Antananarivo The habitat is dominated by tropical, deciduous, dry forest containing several lakes (with areas of 3.1–4.9 km^2) that support 11 fish-eagle territories (Rabarisoa et al. 1997).

On 8 November 1996, a one-footed adult male Madagascar Fish-Eagle was trapped in a territory on Lake Befotaka known as "Befotaka 2." The eagle's right foot was missing, severed at the distal tip of the tarsometatarsus, which had healed over to form a flat-based stump measuring 30 mm × 27 mm. There were no signs of infection and we evaluated the eagle as being in otherwise good condition. An aluminum band (0118) was fitted to the left leg and the eagle was released. A one-footed adult male fish-eagle with an aluminum band on its left leg was resident in the Befotaka 2 territory throughout 1997 and 1998 and was assumed to be the same bird (Kalavah 1997, 1998).

During the 1999–2001 breeding seasons (May–Septem-

ber), daily behavioral observations were made of marked fish-eagles at lakes on the Manambolomaty River floodplain, to document the social interactions of polyandrous breeding trios and quartets (Tingay 2000). Observations were made from land or boat from distances ranging from 5–500 m using 8 × 32 and 10 × 42 binoculars and a 25–60× zoom telescope. Fish-eagles were trapped using either a noosed fish (Wiersma et al. 2001) or a noose carpet (Bloom 1987) and blood samples were taken to conduct DNA studies on paternity and intra-population relatedness (Tingay et al. 2002). Fish-Eagle 0118 was included in this study as he was a member of a breeding trio located within the Befotaka 2 territory.

RESULTS

Survival Longevity. On 18 August 1999, the continued presence of eagle 0118 in Befotaka 2 territory was confirmed when he was re-trapped using a noosed fish and positively identified by the aluminum leg band number. He was re-trapped twice more on 20 August 1999 on both a noose carpet and a noosed fish trap, placed for the second resident adult male fish-eagle from this territory (0008). A one-legged fish-eagle, banded on the left leg and observed in the Befotaka 2 territory during 2000 was assumed to be bird 0118. He was last re-trapped in the Befotaka 2 territory on 4 August 2001 with a noosed fish. A resident one-legged eagle banded on the left leg and present in Befotaka 2 at the time of writing (May 2003) was also assumed to be bird 0118.

Observed Behavior. Fish-eagle 0118 was observed foraging, and involved with courtship and breeding activities. He snatched fish from the lake surface with his left foot and carried it to perch in a tree. He used his left foot to hold the fish in place and used the stump of his right leg to balance, enabling him to lean forward and tear the fish with his beak. Fish-eagle 0118 participated fully in courtship and nesting activities, which included copulation, nest building, incubation and brooding, prey delivery, and nest defense. During copulation, he appeared to use his stump and out-stretched wings to aid his balance, while on the female's back. To facilitate nest building, Madagascar Fish-Eagles fly close to a tree and use both feet to snap off twigs and greenery and deliver them to the nest. Fish-eagle 0118 was observed collecting twigs and greenery successfully in the same manner using only his left foot. This eagle also defended the nest and its immediate vicinity from potential predators such as Yellow-billed Kite (*Milvus aegyptius*; Sinclair and Langrand 1998), Madagascar Buzzard (*Buteo brachypterus*), and Pied Crow (*Corvus albus*), by engaging in aerial pursuits and loud vocalizations with his conspecifics.

Social Status. Fish-eagle 0118 was presumed to be the dominant male in the Befotaka 2 territory, based on his level of paternal investment at the nest and his level of aggression towards the other male (0008) in the territory (Tingay 2000). During each observation period he was aggressive towards eagle 0008, typically supplanting 0008 from either the nest or perches near it. Supplanting was achieved either by flying towards eagle 0008 and emitting the distinctive "displacement call" (Tingay 2000), resulting in 0008 leaving his position before eagle 0118 arrived Alternatively, eagle 0118 landed next to bird 0008 and physically moved 0008 by pushing body against body. On several occasions, eagle 0118 was also observed foot grappling with 0008, typically when eagle 0008 attempted to deliver a stick or greenery to the nest. On these occasions eagle 0118 flew towards 0008, making the displacement call, and attempted to intercept bird 0008's flight to the nest. When eagle 0008 continued towards the nest, bird 0118 pushed out his left foot and 'locked' with one of 0008's feet for several seconds before both released their grip and they separated. Fish-eagle 0118 successfully removed or supplanted 0008 during every observed aggressive act throughout the three breeding seasons (1999–2001).

DISCUSSION

There are several possible explanations to account for the loss of fish-eagle 0118's right foot. He may have become accidentally entangled in a fisherman's net while foraging and had his foot cut off to release him (Rabarisoa et al. 1997). It is possible that eagle 0118 was used to supply eagle body parts to a traditional sorcerer who believed that the addition of an eagle foot or beak to a potion would give it strengthened properties (Kalavah and Razanrizanakanirina 1997). An alternative explanation may be that his foot was removed by locals to obtain a leg band; aluminum leg bands had been mistaken as silver or another precious metal (Kalavah and Razanrizanakanirina 1997). Another possible explanation is that eagle 0118 was the victim of a Nile crocodile (*Crocodylus niloticus*) attack while bathing or drinking at the lake edge, similar to the crocodile attack on an Osprey (*Pandion haliaetus*) reported from West Africa (Hutton 2001).

It has been argued that birds have a limited amount of soft tissue in the distal portion of the leg and a reduced vascular supply to the extremities (Proctor et al. 1993), rendering them with a limited ability to fight foot infection (Durham 1981, Cooper 1985). In addition, the proper distribution of a bird's weight requires the use of both feet; otherwise the additional weight borne by one foot could lead to the deterioration (and thus infection) of the epithelium of the toe pad (McKeever 1979, Durham 1981, Cooper 1985). We suggest that fish-eagle 0118 has used his stump to aid his balance and thus his weight distribution, and may have reduced his susceptibility to these kinds of problems and increased his survival longevity.

Another consideration that may affect the ability of a one-footed raptor to survive in the wild is the bird's ability to forage effectively. Cooper et al. (1980) and Durham (1981) suggest that foot loss may be more of a problem for specialized rapacious species such as Accipiters, but less of a problem for generalist predators such as Buteos. The Madagascar Fish-Eagle is a specialized piscivorous

raptor (Berkelman et al. 1999), yet there is no evidence to suggest that 0118's handicap affected his foraging ability.

Belonging to a breeding trio may have been advantageous for eagle 0118 and could have contributed to his longevity, although other two-footed Madagascar Fish-Eagles also engaged in this breeding strategy (Tingay et al. 2002). Fish-eagle 0118's dominant social status was surprising, as a handicapped eagle may have been expected to be bullied by both conspecifics and other species (Blodget et al. 1990). The fact that eagle 0118 dominated another group member, 0008, suggests that he was not intimidated by conspecifics. Additionally, fish-eagle 0118 was not intimidated by other species, as demonstrated by his frequent involvement in nest defense against potential predators.

Age may also have influenced the dominance hierarchy in this territory. The exact age of eagle 0118 was unknown, although he was in adult plumage when trapped in 1996 and therefore at least 4 or 5 yr old at time of capture, making him at least 11–12 yr old at the time of writing. Fish-eagle 0008 was known to be younger than eagle 0118, as banding records showed he hatched in a neighboring territory in 1993.

While we are not advocating the general release of one-legged raptors to the wild, fish-eagle 0118 may illustrate an important exception to the rule. The Madagascar Fish-Eagle is considered critically endangered (Collar et al. 1994) with a census population currently estimated at 222 individuals (Rabarisoa et al. 1997). The effective population size of any species is usually smaller than the census population size (Lande and Barrowclough 1993) and thus every potential breeding fish-eagle adult is important to the overall genetic diversity of the species. Fish-eagle 0118 is known to possess at least one rare allele shared with only one other eagle in the area (Tingay et al. 2002) making him a potentially critical genetic contributor. His 7-yr survival in the wild as well as holding a socially dominant position in the group demonstrates his ability to adapt, and provides an alternative management option to the capture and retention in captivity of disabled individuals of endangered species.

Resumen.—Reportamos la supervivencia por 7 años en vida silvestre de un águila-pescadora de Madagascar con una sola pata y documentamos su estatus social como macho dominante dentro de un trío poliándrico. Esta águila pescadora fue observada forrajeando exitosamente y participando en actividades reproductivas tales como copulación, construcción del nido, incubación, empollamiento, entrega de presas y defensa del nido.

[Traducción de César Márquez]

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Literature Cited

Berkelman, J., J.D. Fraser, and R.T. Watson. 1999. Madagascar Fish-Eagle prey preference and foraging success. *Wilson Bull.* 111:15–21.

Blodget, B.G., W.J. Davis, and M. Pokras. 1990. Bald Eagle survives two years in wild with one foot. *J. Field Ornithol.* 61:76–78.

Bloom, P.H. 1987. Capturing and handling raptors. Pages 99–123 *In* B.A. Giron-Pendleton, B.A. Millsap, K.W Cline, and D.M. Bird [Eds.], Raptor Management Techniques Manual. National Wildlife Federation, Washington, DC U.S.A.

Collar, N.J., M.J. Crosby, and A.J. Stattersfield. 1994 Birds to watch 2: the world list of threatened birds BirdLife International, Cambridge, U.K.

Cooper, J.E. 1985. Veterinary aspects of captive birds of prey. The Standfast Press, Gloucestershire, U.K.

———, L. Gibson, and C.G. Jones. 1980. The assessment of health in casualty birds of prey intended for release. *Vet. Rec.* 10:340–341.

Durham, K. 1981. Injuries to birds of prey caught in leghold traps. *Int. J. Study Anim. Prob.* 2:317–328.

Eggenhuizen, T. 1995. Capture of a one-legged kestrel (*Falco tinnunculus*). *Limosa* 68:119–120.

Hutton, J. 2001. Crocodile eats rare Scottish Osprey. *Croc. Spec. Group Newsletter* 20:8.

Kalavah, L. 1997. Annual Field Report. The Peregrine Fund, Antananarivo, Madagascar.

———. 1998. Annual Field Report. The Peregrine Fund, Antananarivo, Madagascar.

——— and D. Razanrizanakanirina. 1997. Socio-economic status in 1996 of the region around the three lakes, Befotaka, Soamalipo, and Ankerika, in western Madagascar. The Peregrine Fund, Boise, ID U.S.A.

Lande, R.L. and G.F. Barrowclough. 1993. Effective population size, genetic variation, and their use in population management. Pages 87–123 *in* M.E. Soulé [Ed.], Viable Populations For Conservation. Cambridge Univ. Press, Oxford, U.K.

McKeever, K. 1979. Care and Rehabilitation of Injured Owls. W.F. Rannie, Ontario, Canada.

PROCTOR, N.S., R.T. PETERSON, AND P.J. LYNCH. 1993. Manual of ornithology: avian structure and function. Yale Univ. Press, Hartford, CT U.S.A.

RABARISOA, R., R.T. WATSON, R. THORSTROM, AND J. BERKELMAN. 1997. Status of the Madagascar Fish-Eagle in 1995. *Ostrich* 68:8–12.

SINCLAIR, I. AND O. LANGRAND. 1998. Birds of the Indian Ocean Islands Madagascar, Mauritius, Reunion, Rodrigues, Seychelles and the Comoros. Struik Publishers (Pty) Ltd., Cape Town, South Africa.

TINGAY, R.E. 2000. Sex, lies, and dominance: paternity and behaviour of extra-pair Madagascar Fish-Eagles *Haliaeetus vociferoides*. M.S. thesis, University of Nottingham, Nottingham, U.K.

———, M. CULVER, E.M. HALLERMAN, R.T. WATSON, AND J.D. Fraser. 2002. Subordinate males sire offspring in Madagascar Fish-Eagle (*Haliaeetus vociferoides*) polyandrous breeding groups. *J. Raptor Res.* 36:280–286.

WATSON, R.T., J. BERKELMAN, R. LEWIS, AND S. RAZAFINDRAMANANA. 1993. Conservation studies on the Madagascar Fish-Eagle *Haliaeetus vociferoides*. *Proc. Pan-Afr Ornithol. Congr.* 8:192–196.

WIERSMA, J.M., W. NERMUT, AND J.M. SHEPHARD. 2001. A variation on the 'noosed fish' method and its suitability for trapping the White-bellied Sea Eagle *Haliaeetus leucogaster*. *Corella* 25:97–99.

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REPRODUCTIVE SUCCESS OF SPOTTED OWLS SYMPATRIC WITH BARRED OWLS IN WESTERN WASHINGTON

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KEY WORDS: *Northern Spotted Owl*; Strix occidentalis caurina; *northern Barred Owl*; Strix varia varia; *competition*; *Washington*.

Northern Barred Owls (*Strix varia varia*) and northern Spotted Owls (*Strix occidentalis caurina*) in western Washington use similar forested habitats (Herter and Hicks 2000) and demonstrate some niche overlap in their predation upon small mammals (Hamer et al. 2001). Both owls also use similar tree cavities for nesting (Hamer 1988). Because Barred Owls are larger (Dunning 1992) and exhibit more pronounced territorial behavior (Hamer et al. 2001), many biologists have expressed concern that Barred Owls may pose a significant obstacle to the successful recovery of the threatened northern Spotted Owl. Kelly et al. (2003) found that Spotted Owl site occupancy was negatively affected by close proximity to Barred Owls in forests on the eastern slope of the Washington Cascades and on the Olympic Peninsula. Recently, Pearson and Livezey (2003) observed that the loss of mature forest habitat may reduce the survivability of Spotted Owls in the presence of Barred Owls. My study examined potential effects of Barred Owls on Spotted Owl reproductive success on the western slope of the Washington Cascades.

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STUDY AREA AND METHODS

Located on the western slope of the Washington Cascades (ca. 47°–49°N, 121°–122°W), the Mount Baker-Snoqualmie National Forest (MBSNF) is ideally suited to evaluate effects of interactions between Spotted and Barred owls. The two species have co-occurred in this area for over 20 yr (Taylor and Forsman 1976). Spotted Owls in the MBSNF are near the northern limit of their range and are less productive than owls in warmer or drier parts of their range (Iverson 1996). Therefore, Spotted Owls in the MBSNF might be expected to be more vulnerable to potential exclusion by more aggressive Barred Owls.

Reproductive success is an important component of individual fitness. For the purposes of this study, I defined reproductive success as the production of young in one or more survey years. If competition (or predation) by Barred Owls were a significant threat to Spotted Owls, one would expect to see reduced reproductive success of Spotted Owl activity centers that are coincident with Barred Owls. Spotted Owl activity centers in this study were determined by a hierarchical system, with a nest site being the most reliable definition, followed by owls with young, consistent daytime location, and consistent nighttime location (U.S. Forest Service 1988). Using the mean annual home range estimate for Spotted Owls (3-km radius circle) and Barred Owls (1.5-km radius circle) in this area (Hamer 1988), it is very likely that Barred Owls found consistently within 2.5 km of Spotted Owl activity centers have home ranges that overlap those of Spotted